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INFLUENCE OF THE METAL-FRAME ON THE PERFORMANCE OF A MIMO ANTENNA

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ABSTRACT

In this paper, the effect of the metal-frame on the performance of a MIMO antenna on the Tablet PC is investigated. The antenna composed of two radiating elements, which can cover 690MHz～960MHz、1710MHz～2170MHz, and 2500MHz～2700MHz bandwidths. Without the metal-frame, the isolation between the two radiating elements is larger than 10 dB. With a full metal-ring, the isolation is decreased. To solve this problem, a gap is cut on the metal-ring and the metal-ring is also connected to the system ground. By this way, the isolation can be restored to be larger than 10 dB.

KEYWORDS: Metal-Frame, MiMo Antenna, LTE Band & Table PC

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Original Article

INTRODUCTION

Background/ Objectives and Goals

The metal-frame is often placed external to a mobile phone, a Tablet PC, or a smart watch. In case that, the metal-frame is demanded for mechanical or for aesthetic reason, the influence of the metal-frame for the performance of the antenna needs to be evaluated. In [1-2], the metal-frame was treated as an external antenna for the single SISO system. It is demonstrated that gaps loaded with or without resistive elements in the metal-frame are required to restore the desired performance of the antenna, originally achieved through the internal antenna. In [3], the metal-frame acts as the radiating element in the SISO system and the desired performance is achieved with the help of a band pass filter. In [4], the metal-frame is used as the antenna of a smart watch to cover a narrow bandwidth centered at 2.45 GHz. In [5], two dual-element MIMO antennas have been presented. Each antenna consists of two radiating elements. One antenna is responsible for cellular communication and the other one is for the Wi-Fi communications. The two antennas, also used as the metal-frame, are of the ring-type antennas. In this paper, the metal-frame is separated from the dual-element MIMO antenna. The difference in performance of the antenna with and without the metal-frame in such an arrangement has not been reported in the literature. Therefore, the purpose of the paper is to investigate the effect of the metal-frame. In this study, two coupled meandered lines will be used as the radiating element. The two elements are placed on the topside of the system ground.

METHODS

Figure 1 shows the proposed MIMO antenna. It is intended to cover three bandwidths: 690 MHz to 960 MHz, 1710 MHz to 2170 MHz, and 2480 MHz to 2690 MHz. The two radiating elements are printed on 0.6 mm thickness single-layer FR4 substrate, and are placed symmetrically with respect to the center line. The system ground is dimensioned with 240 mm x 140 mm x 1 mm and a metal-frame dimensioned with 258 mm x 178 mm x 1

mm is surrounding the two radiating elements. It is also noted that there is a gap in the metal-frame. The gap is 23 mm in the horizontal direction and 3 mm in the vertical direction. The system ground and the metal-frame are connected by two strips; each strip is dimensioned with 6 mm in length and 3 mm in width. One can check that the height of the antenna is 20 mm. The main parameters related to each radiating element are listed in Table 1.

Table 1: Dimension (in mm) of the Main Parameters in Each Radiation Element

Parameter	A	B	C	D	E	F	G	H	I	J	K
Value	60	5.5	23	7	2	4	16.75	3.5	12	0.5	75.5

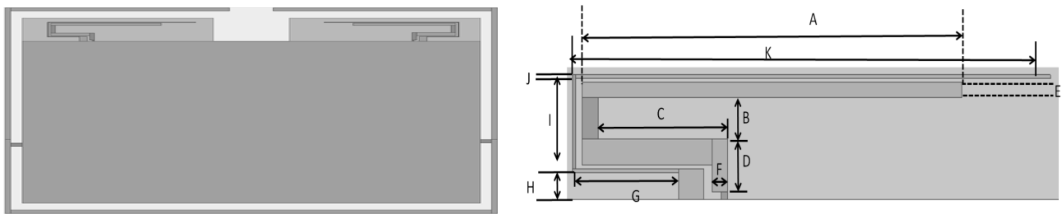


Figure 1: The Proposed Antenna

The metal frame is introduced to increase the isolation. A step-by step analysis will lead the final configuration of the proposed structure. Figure 2 shows a comparison of the isolation of the two radiating elements with and without a rectangular metal frame.

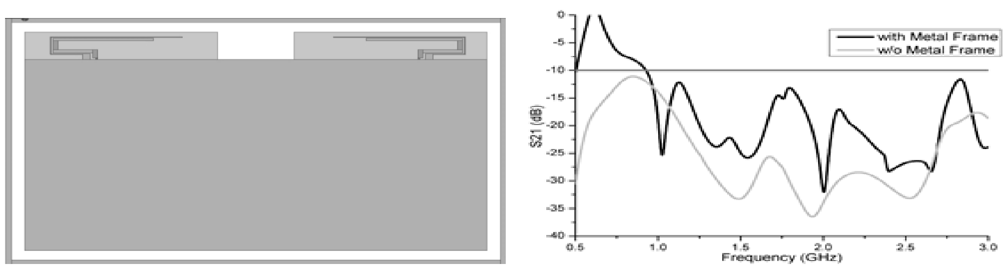
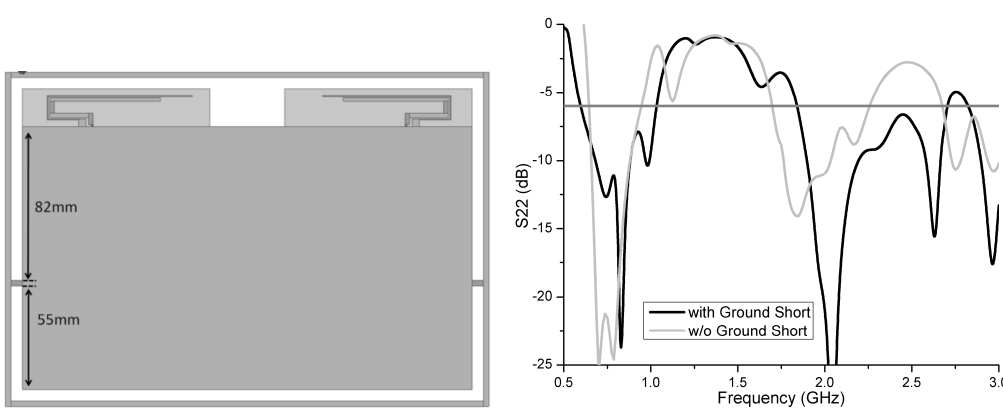


Figure 2: A Comparison of the Isolation with and without a Rectangular Metal-Frame

It is shown in Figure 2 that the isolation becomes worse with the rectangular metal-frame. As for S11 and S22, we found that both S-parameters can meet the requirement (VSWR<3) to cover the demanded bandwidth. Since the antenna is sometimes surrounded by the metal-frame for mechanical or aesthetic reasons, a method should be presented to increase the isolation when the antenna is surrounded by a metal-frame. In Figure 3, two strips are added to connect the rectangular metal -frame and the system ground. The S-parameters of the associated antennas are compared.



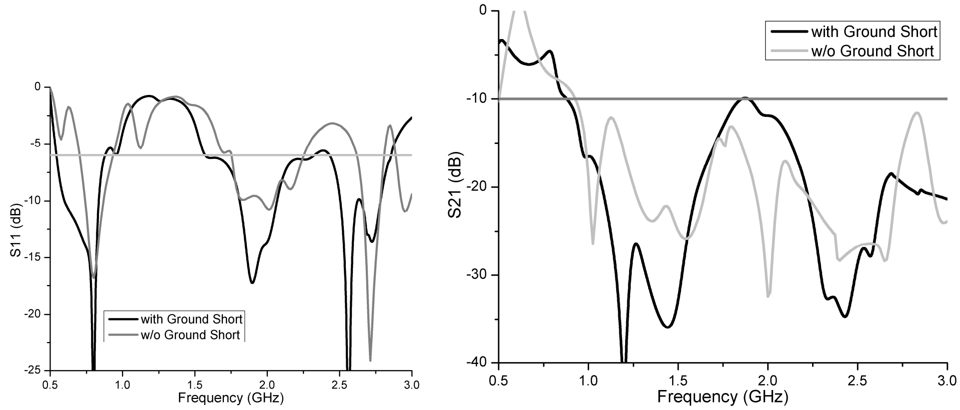


Figure 3: A Comparison of S11, S22, and S21 of the Antenna with and without the Connected Strips (the Ground Short)

It is shown in Figure 3 that by adding the grounded strips to the rectangular frame can effectively decrease the lowest operating frequency of the antenna. However, the improvement on the isolation is not apparent. We then propose the configuration shown in Figure 4. In this case, a gap is cut on the top-edge of the grounded metal-frame. It is shown that the isolation between the two radiation elements is largely increased. The isolation between them over 690 MHz to 960 MHz (the lower-part bandwidth of the mobile communication) is about 11 dB. The isolation above 1.1 GHz is greater than 15 dB.

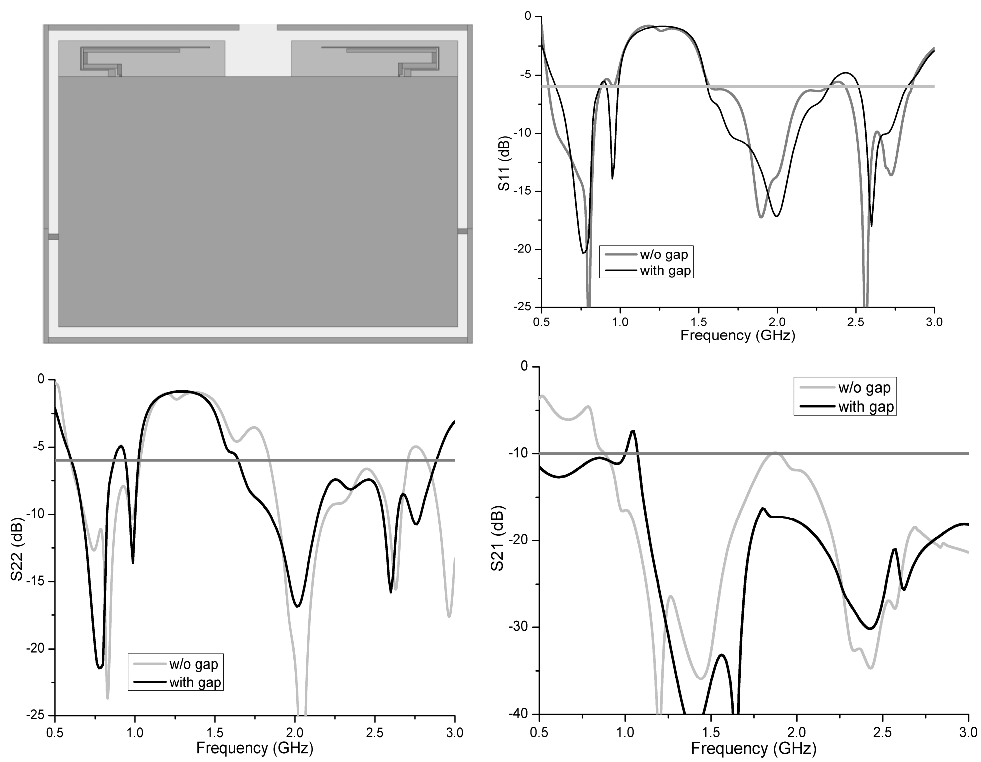
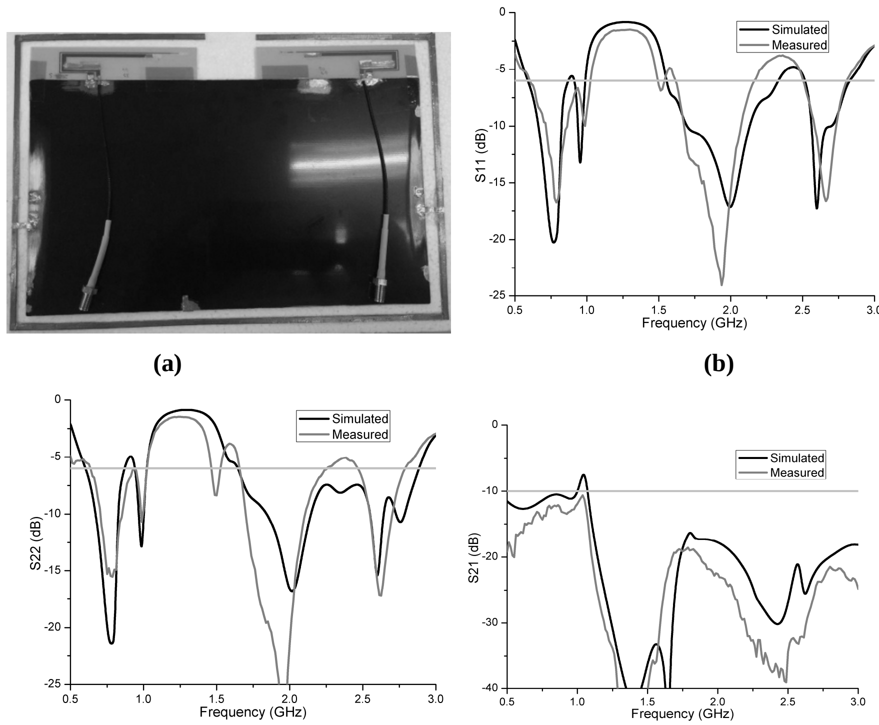


Figure 4: A Comparison of S11, S22, and S21 of the Antenna with and without the Gap on the Metal-Frame

MEASUREMENTS

A picture of the proposed antenna is shown in Figure 5a. Simulated and measured S parameters are shown in Figure 5b for S11, Figure 5c for S22 and Figure 5d for S21. We can see that good agreements are found between each set of the S-parameters. In measurements, the lower-part bandwidth of the first radiating element is 425 MHz, from 600 MHz to 1025 MHz. The lower-part bandwidth of the second radiating element is 387 MHz from 638 MHz to 1025 MHz. Each radiating element is also well matched from 1710 MHz to 2170 MHz and from 2480 MHz to 2690 MHz. As for the isolation, it is above 20 dB on the higher-part band and about 11 dB on the lower-part band.



(a) (b)

(c) (d)

Figure 5: The Picture of the Proposed Antenna and the S-Parameters Associated with the Antenna

The measured efficiency and peak-gain of the proposed antenna are respectively shown in Figure 6 and Figure 7. Both the efficiency and the peak gain are measured in the two radiating elements. The efficiency and gain of the first and the second radiating elements are quite similar.

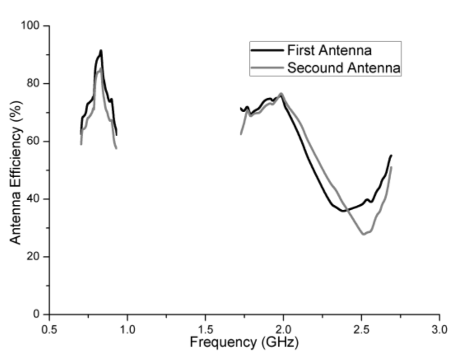


Figure 6: Efficiency of the Proposed Antenna

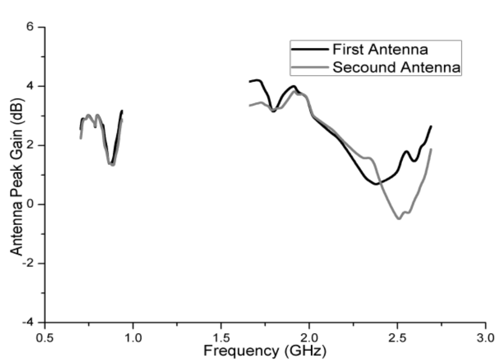
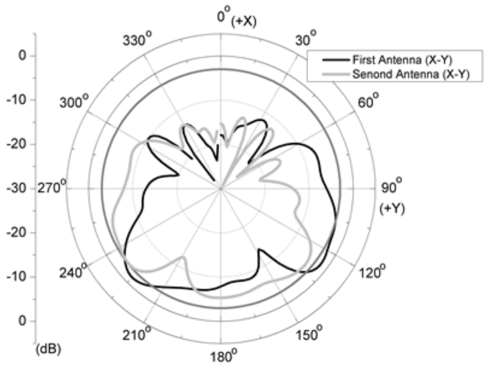
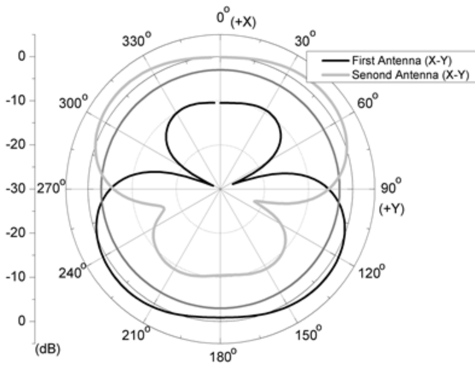


Figure 7: Peak Gain of the Proposed Antenna

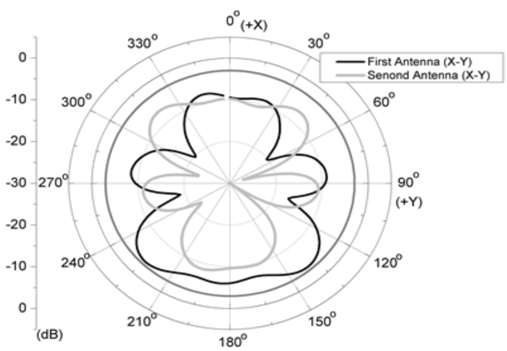
The radiating patterns at xy-plane of proposed antenna at four frequencies are shown in Figure 8. In Figure 9, the yz-plane patterns are shown. Measurements are separately made for the two radiating elements.



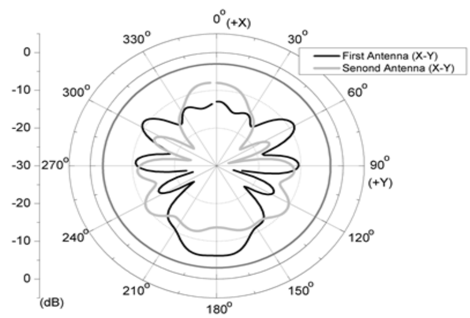
(a) 690 MHz



(b) 960 MHz

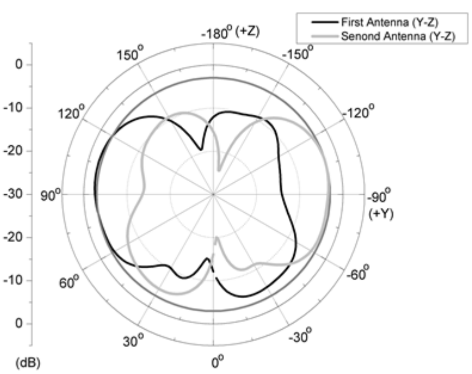


(c) 1710 MHz

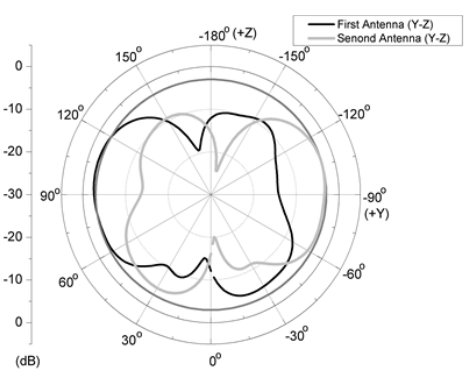


(d) 2710 MHz

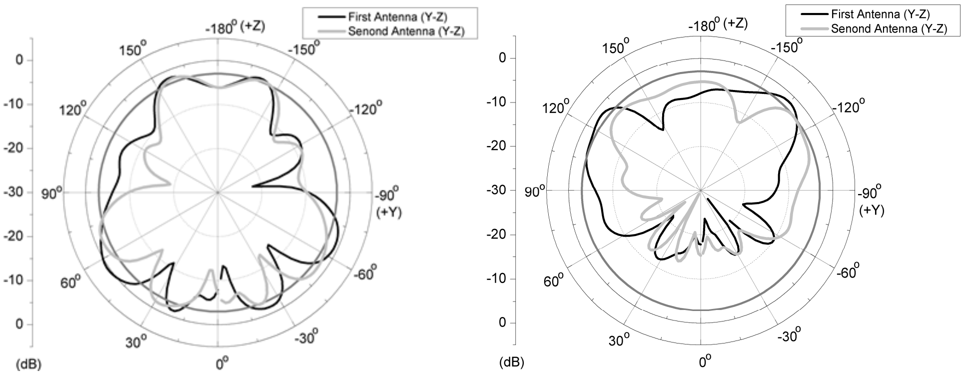
Figure 8: Measured xy-Plane Radiation Patterns of the Propose Antenna



(a) 690 MHz



(b) 960 MHz



(c) 1710 MHz **(d) 2710 MHz**

Figure 9: Measured yz-Plane Radiation Patterns of the Propose Antenna

CONCLUSIONS

A preliminary study of the isolation between two radiating elements of a dual-element MIMO antenna with a metal-frame is presented. The cut on the metal-fame is found necessary to increase the isolation on the lower-part bandwidth. For the higher-port bandwidth, the cut does not help in increasing the isolation too much. It is also found that the grounded strip connected to a rectangular frame can lower down the lowest operating frequency. For single radiating element surrounded by a metal-frame, we have studied that the lowest operating frequency is 500 MHz/690 MHz for the same sized element with/without the grounded strip. However, for dual-element in the MIMO antenna, the decrease in the lowest operating frequency is not very apparent. In the literature, the metal-frame itself may be designed as the radiating antenna [5] in a MIMO system. In [5], the isolation is 4 dB in the lower-part band. The isolation of our antenna in the lower-part band is about 11 dB.

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